EARTHQUAKE

OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

An **Earthquake** is a sudden release of energy from the earth's crust that creates seismic waves. Stress is created in the earth's crust from thermal variations, tectonic changes, and other forms of pressure. Weaknesses in the earth crust yield when the stresses exceed the friction along these crustal weaknesses, and an earthquake happens. At the earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground.

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Earthquake Risk Profile				
	Risk Assessment Category	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
LIKELIHOOD	**Likelihood**	2 Infrequent		50%
CONSEQUENCE	**Impact**	1 Limited	3.5 Critical-Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	4 Very Long	5%
TOTAL RISK SCORE		**1.6**	**2.6**	

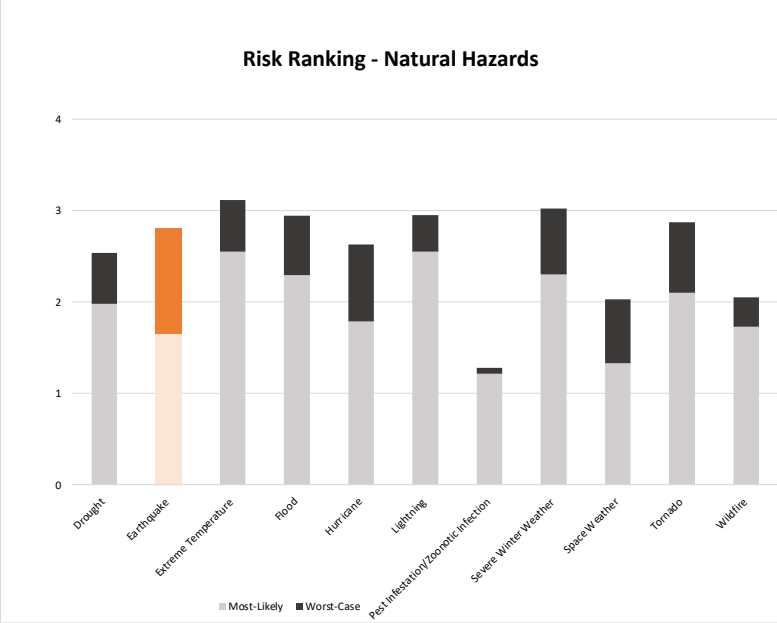
**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

Risk Matrix

The Risk Matrix is a graphical illustration of hazard risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the hazard.

Risk Ranking

The Risk Ranking is a graphical illustration of hazard risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

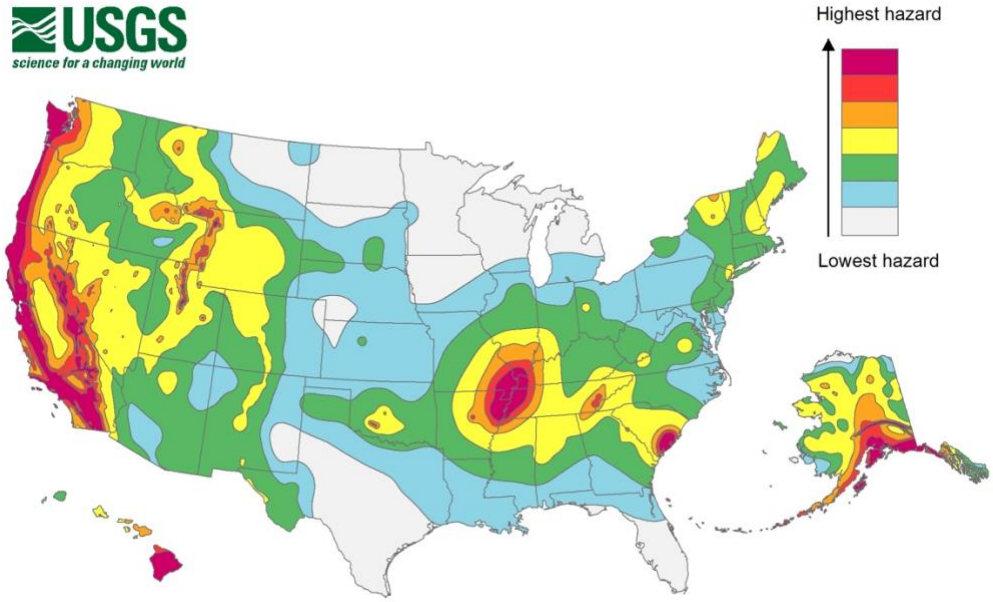
An **Earthquake** is a sudden release of energy from the earth's crust that creates seismic waves. Tectonic plates become stuck, thus putting a strain on the ground. When the strain becomes so great that rocks give way, fault lines occur. At the Earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground. This may lead to loss of life and destruction of property. The size of an earthquake is expressed quantitatively as magnitude[1], while local strength of shaking is expressed as intensity.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

The entire County is susceptible to the effects of earthquakes. The map shown below was produced by the 2018 U.S. Geological Survey National Seismic Hazard Mapping Project. "The 2018 Update of the U.S. National Seismic Hazard Model defines the potential for earthquake ground shaking for various probability levels across the conterminous United States and is applied in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy."[2]

[1] The inherent size of an earthquake is commonly expressed using a magnitude.
[2] United States - Lower 48 Seismic Hazard long term model. Retrieved from https://www.usgs.gov/programs/earthquake-hazards/science/2018-united-states-lower-48-seismic-hazard-long-term-model (last accessed September 24, 2022).



Howard County has a particular vulnerability to earthquakes for several reasons. Most buildings in the County are not built to earthquake-resistant requirements. Also, because earthquakes have historically happened so infrequently in the area, most residents are not as familiar with what to do during an earthquake. The County also has a high prevalence of nursing homes, which could present additional earthquake vulnerabilities for community members with access and/or functional needs.

LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

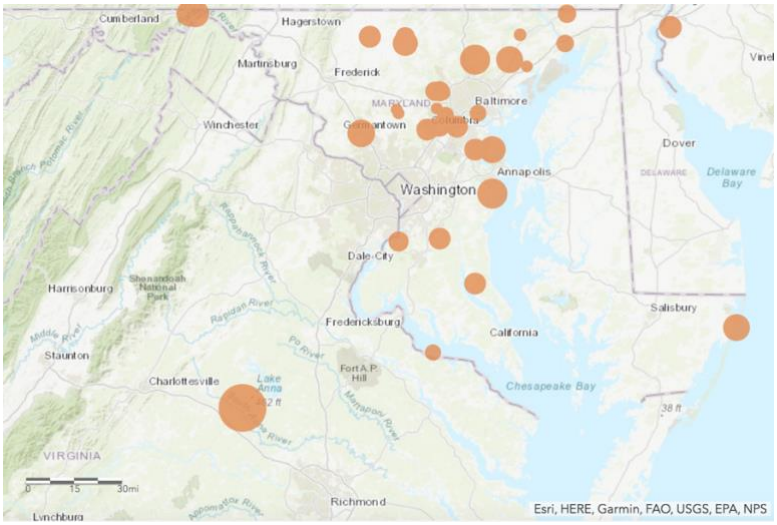
Data from the Maryland Geological Survey (MGS) indicates there have been 70 earthquakes with epicenters in Maryland between 1758-2017.[3] The USGS shows the earliest recorded earthquake with its epicenter in Maryland occurred in Annapolis on April 24th, 1758. The shock lasted 30 seconds and could be felt as far away as Pennsylvania. In recent years, moderate-sized earthquakes which occurred in nearby states have been felt in Maryland with only minimal effects. On November 19th, 1969, a 4.3 magnitude earthquake near Elgood, West Virginia was felt in Central Maryland, including Howard County. On February 28th, 1973, residents throughout the Mid-Atlantic region were jolted awake by

[3] These numbers reflect the most up to date data according to the Maryland Geological Survey. Events that may have occurred since 2017 are not listed. Citation: Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed December 16, 2022).

shock waves from a minor earthquake near the Delaware/New Jersey/Pennsylvania border. Numerous points in Northeastern Maryland reported this earthquake.[4]

Maryland's USGS earthquake history was reviewed to identify past earthquake occurrences that have impacted Howard County. According to the USGS, there were 18 notable earthquake incidents in Howard County, Maryland since 1991.[5] The strongest magnitude event was a magnitude 2.7 event that occurred near Columbia, MD in 1993. More recently Howard County has experienced a magnitude 2.1 event in August of 2021 and a magnitude 2.0 event in October of 2022. The likelihood of significant earthquake damage in Howard County is low since the probability of the area being stricken by an earthquake is relatively low as compared to other parts of the country. Even though earthquakes do occur occasionally, the County is in an area of very low seismic activity.

Approximate Epicenter of Maryland Earthquakes since 1758



(Source: Maryland Geological Survey)[6]

Notable Incidents Within Howard County

November 1969	On November 19th, 1969, a 4.3 magnitude earthquake near Elgood, West Virginia was felt in central Maryland, including Howard County.[7]

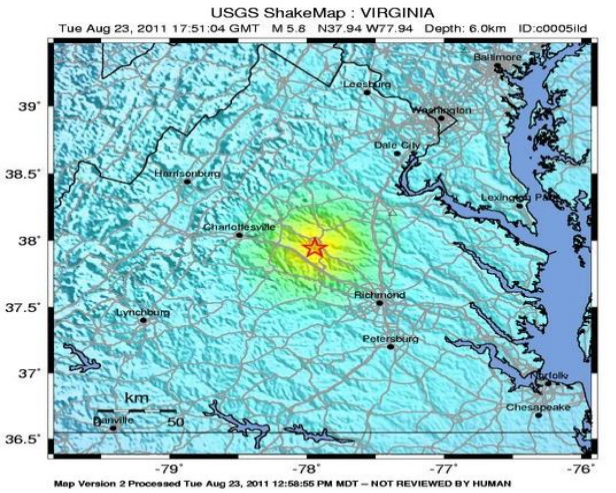
[4] See Earthquakes and Maryland, http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed September 24, 2022).
[5] Search Earthquake Catalog. Retrieved from shorturl.at/noPS0 (last accessed November 24, 2022).
[6] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed September 24, 2022).
[7] Southern California Earthquake Center. The Great SouthEast ShakeOut. Retrieved from https://www.shakeout.org/southeast/maryland/ .

March – December 1993	From March through December 1993, data indicated that a series of two-dozen small tremors occurred near Columbia, Maryland, ranging in magnitude from >1 to 2.7 on the Richter Scale.[8]
August 2011	On August 23rd, 2011, Maryland experienced the effects of a nearby earthquake when a 5.8 magnitude quake centered in Virginia impacted much of the East Coast. Tremors were felt as far south as North Carolina, as far north as Buffalo and Boston, and as far west as Detroit. The epicenter of the earthquake was about 3.5 miles beneath Mineral, Virginia, which is 35 miles northwest of Richmond. The USGS indicated the earthquake was one of the strongest ever to occur in Virginia and the strongest felt in Maryland. After the ground shook for several seconds, buildings were evacuated, and some businesses and agencies shut down for the afternoon. Rail travel was interrupted, and many commuters faced an early, congested rush hour.[9] Damage inspections after the earthquake found structural damage was limited, although in some areas there were significant localized damages. In Howard County, many residents were startled by the earthquake but there was no significant damage or injuries reported. The figure below is a USGS "shake map" that shows the intensity of shaking from the Mineral, Virginia earthquake. Note that the area west of Baltimore, where Howard County is located, experienced weak to low shaking intensity and no expected damages.
October 2017	October 30th, 2017, an earthquake with a magnitude of 1.52 occurred in Glenelg.
November 2017	November 11th, 2017, an earthquake with a magnitude of 1.5 occurred in Roxbury.
August 2021	August 4th, 2021, an earthquake with a magnitude of 2.1 occurred in Clarksville.
October 2022	October 10th, 2022, an earthquake with a magnitude of 2.0 occurred in Sykesville.

USGS Shake Map for the Mineral, Virginia Earthquake of 2011

[8] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html.

[9] Calvert, Scott and Childs Walker, *Earthquake in Virginia Rattles Baltimore and the East Coast*, Baltimore Sun, August 23, 2011.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Future Likelihood for Howard County - Earthquake

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of an Earthquake in Howard County	
Historical Average (time period)	18 events (1992-2022)
Historical Annual Probability	30% + chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score	2 (Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

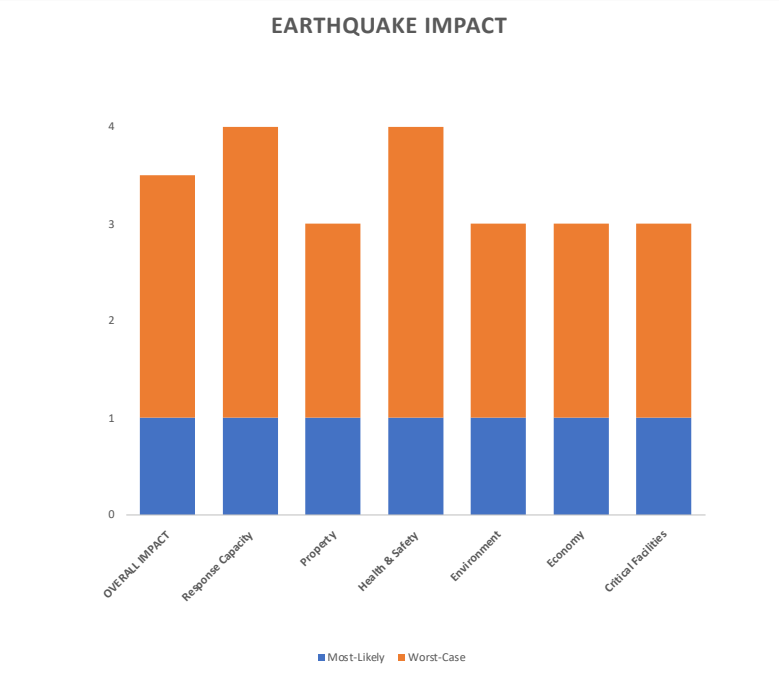
Considerations: While there is a very likely chance (30%+) of *any* earthquake occurring annually based on historical data, most earthquakes would be low enough in intensity that most community members would not feel them. The historical number of earthquakes is therefore higher than the future likelihood of the hazard occurring. The future annual probability of an earthquake is 1-10% chance of annual occurrence, or one event every 10-99 years. One consideration that could impact the future likelihood of the hazard occurring is if there is an increase in fracking[10] within the County.

[10] Fracking is defined as "Hydraulic fracturing (informally known as hydrofracking, fracking, fracing, or hydrofracturing) is a process that typically involves injecting water, sand, and chemicals under high pressure into a bedrock formation via a well. This process is intended to create new fractures in the rock as well as increase the size, extent, and connectivity of existing fractures in order to extract trapped oil and gas." (Citation: USGS. Hydraulic Fracturing. Retrieved from https://www.usgs.gov/mission-areas/water-resources/science/hydraulic-fracturing?qt-science_center_objects=0#qt-science_center_objects, last accessed December 29, 2019.)

CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Earthquake - Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time.	*Short.* No warning time.
DURATION	*Short.* 15 seconds.	*Very Long.* Two minutes of shaking. Hazardous conditions due to expected damage could persist for at least one week

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Earthquake - Consequence Analysis Likely				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure are not damaged. ▪ No structural damage expected.		
HEALTH AND SAFETY	*Limited*	▪ *Health*- Zero deaths are expected. Being crushed by structural damage is the most common cause of death. ▪ *Health*- Zero to five injuries are expected. Broken or fractured bones and internal bleeding are the most common causes of injuries.		
CRITICAL FACILITIES	*Limited*	▪ Utilities – Water lines would be the only essential functions that will be out of service. Other outages unlikely. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* –Impacts if any to transportation will be minor and short-term.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Local resources adequate. Should not impact operations. May require damage assessment teams. ▪ *Health* – Local resources adequate. HD operations will not be affected after building has been cleared to be safe by emergency/ facility personnel. ▪ *Public Works* – Local resources adequate with no impact response capability and continuity of operations.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal environmental impact on air, water, and land is expected. ▪ Limited environmental impact is expected.		
ECONOMIC IMPACT	*Limited*	▪ Limited economic impact.		
TOTAL IMPACT	***Limited***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Earthquake - Consequence Analysis **Worst-Case**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Critical*	▪ Most critical and non-critical infrastructure will be damaged. ▪ Chimney collapses on homes, historic building collapse, oil and gas pipeline shutdowns and inspections, hospital operating room shutdowns, elevator shutdowns, garage doors inoperable due to frame shifting. Hardened structure shifting, foundation shifting and damage, infrastructure cracks and damage causing gas and water leaks, damage to bridges and overpasses.
HEALTH AND SAFETY	*Catastrophic*	▪ Minimal deaths are expected. Being crushed by structural damage are the most common causes of death. ▪ 100-200 injuries are expected. Broken or fractured bones and internal bleeding are the most common causes of injuries.
CRITICAL FACILITIES	*Critical*	▪ *Transportation* – Transportation, water service, wastewater, landfill, transfer station, and fire stations will be out of service. ▪ *Information/Communications* – Significant/extended outage expected. ▪ *Utilities* – Hardened structure shifting, foundation shifting and damage, infrastructure cracks and damage causing gas and water leaks and limited power loss.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Moderate need for state or federal assistance. Moderate impact on law enforcement due to security detail, traffic detail, and increased response to hazard calls. Additional resources required from Sherriff's office and possible State police. ▪ *Fire and Rescue* – Severe and long-lasting need for state or federal assistance. Significant impact to response capability, alternate work schedules may be required, USAR, DMAT, maybe DMORT. COOP Plans will be needed. ▪ *Health* – Moderate need for state or federal assistance. HD has COOP plans in place to ensure essential functions continue either on site (if possible) or at an alternate location. ▪ *Public Works* – Moderate to significant and long-lasting need for state or federal assistance with severe impact to response capability and COOP.
ENVIRONMENTAL IMPACT	*Critical*	▪ Minimal direct impact on air, water, and land resources. May cause a loss of individual animals and plants. ▪ Infrastructure damage can cause air, water, or land pollution if it disrupts facilities such as pipelines carrying hazardous materials industrial manufacturing plants, or sewage treatment plants.
ECONOMIC IMPACT	*Critical*	▪ Millions of dollars lost in economic activity. ▪ Business, government, and retail closures and residential dislocation with a minimum of one to two-week evaluations before recovery begin in economic consequences.
TOTAL IMPACT	***Critical-Catastrophic***	▪ **Total Impact Score: 3.5 on a scale of 1 (Limited) to 4 (Catastrophic).**
Limited	*Significant*	*Critical* / *Catastrophic*

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Earthquake - Public Perception

Perceived confidence in Howard County's ability to respond and recover from this hazard	*Perceived confidence in their personal ability to protect self and family from this hazard*	*Concern over the impact to personal health and safety if this hazard were to occur locally*	*Concern over the impact to personal standard of living or quality of life if this Hazard were to occur locally*